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REMARKS/ARGUMENTS

Applicant responds herein to the Office Action dated January 29, 2003. A Petition for Extension of Time and the fee therefor are enclosed.

The applicant has responded to the objections to the specification and has provided a substitute specification. No new matter has been added.

The applicant has further responded to the claims objections and to the claim rejection as set forth in paragraphs 7 and 9 of the Office Action. Reconsideration and withdrawal of the objection and rejection under §112 is respectfully solicited.

Substantively, claims 1, 13-16 and 20-22 are stated to be anticipated by Takayama, et al. (6,076,253) and claims 2-5 are stated to be obvious over Takayama, et al., in view of Harada, et al. (6,070,787). Reconsideration of this rejection is requested in view of the amendments to the claims herein and the following remarks.

Claim 1, as originally phrased, and as further amended herein, specifically requires the step of the coil pattern being initially formed on the surface of the cylindrical body and thereafter that cylindrical body being transformed into a square-shaped body by being inserted into a square-shaped mold and by having pressure applied to the inserted cylindrical body at a certain temperature, to cause that physical transformation.

The contention that claim 1, as well as claims 13-16 and 20-22 are "anticipated" by Takayama, et al. cannot be sustained given that anticipation requires virtual identity between the claim subject matter and what is disclosed in the prior art. No cylindrical body is transformed into a square-shaped body in the Takayama, et al. reference. Therefore, there cannot be "anticipation".

Takayama, et al. describes a method for manufacturing a chip inductor in which kneaded material in the form of powdered magnetic material and a binder are fed under pressure to a primary extruder. This initial process produces a winding core which emerges from the extruder at a speed of 30 meters per minute, for example. This bar-body has a circular cross-section and, after it is dried in a dryer, a conducting wire is wound by a winding device around the circular, bar-like body.

This bar-like body with the winding on it, is fed to a secondary extruder in which the round body is coated by another kneaded material, which passes through a generally square-shaped extruder. This outer coating is represented by the material 12 in Figure 2.

The entire process of the present invention which involves the reshaping of a solid body which is initially round, into a square-shaped body, is missing in this reference. An anticipation-based rejection is simply inappropriate in this instance.

Furthermore, with reference to Figure 2, it must be appreciated that the method of this reference involves the continuous production of the device at a rate or a speed of 30 meters per minute in an apparatus which has a mixing part, two extruding parts and a wiring part. To the contrary, the very notion of a continuous process is inapplicable to the present invention (claim 1) in which a round body has to be physically placed in a square mold, and therefore have pressure applied to it, which negates a continuous process. Nor, of course, is there any disclosure in this primary reference that would render the rejected claims 1, 13-16 and 20-22 obvious.

The secondary reference, Harada, et al., which has been applied to claims 2-5, discloses a method for manufacturing a chip resistor, in a non-continuous process. In this method, a resistance conductor is formed on the entire surface of a grind unit element by using thin-film forming techniques, such as sputtering or vacuum deposition, or by using thick-film forming techniques, such as paste coating. The resistor conductor is then subjected to trimming for adjusting the resistance value. More specifically, a groove is formed in the resistance conductor on the hourglass-shaped part, while bringing a resistance value detecting terminal into contact with prism-shaped parts 2a, to regulate and control the resistance value. The groove may be formed through a partial grinding by a grinding blade, or alternatively, may be formed through partial melting by means of a laser beam that is operable in the infrared region.

This film forming technique which utilizes sputtering, vacuum deposition or paste coating, cannot be easily matched with any continuous process as is described in the primary Takayama, et al. reference and certainly cannot be applied at speeds of 30 meters per minute. Moreover, the grooving-forming technique disclosed by Harada, et al. are difficult to apply to the fast, continuous process in the primary reference. This militates against the application of any coating technique as disclosed in claims 2-5 to the primary reference, as suggested by the Examiner. One of ordinary skill in the art would not find such a combination obvious and the

differing technology actually negates the obviousness assertion in this Office Action. Accordingly, it is submitted that claim 1 and every one of the claims that depend therefrom, are clearly patentable over the prior art.

Accordingly, the Examiner is respectfully requested to reconsider the application, allow the claims as amended and pass this case to issue.

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as First Class Mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on May 29, 2003:

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Name of applicant, assignee or Registered Representative

Signature

May 29, 2003
Date of Signature

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METHOD FOR FABRICATING SURFACE MOUNTABLE CHIP INDUCTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method for manufacturing a chip inductor, and in particular to a method for manufacturing a surface mountable chip inductor used for electric appliances, etc.

2. Description of the Prior Art

A chip inductor is used for various electric appliances such as an electronic home appliances as well as an electronic industrial equipment, etc. Recently, ~~according~~ responsive to miniaturization and lightweight trends of various electric appliances, electric parts constructing electric appliances are also being miniaturized and ~~light-weighted~~ rendered lighter. In the meantime, according to development of digital communication, ~~a used~~ the frequency being used is gradually extended to a high frequency region, and accordingly, electromagnetic ~~wave environment has~~ interference conditions have deteriorated. Most of electronic devices are surface-mounted on a printed circuit board ~~for automation of~~ to automate fabrication ~~process~~ processes. However, because the surface-mounted devices have a square shape, the conventional cylindrical inductor has difficulty in surface mounting.

An inductor is divided into a wire wound type and a stacked type, each ~~has~~ having different application ~~field~~ fields and fabrication ~~method~~ methods.

In a wire wound type inductor, a coil is wound on a base body such as a magnetic material, etc. In this case, as the number of winding increases in order to get a high inductance, a high frequency characteristic deteriorates according to increase of the number of winding, because ~~a~~ stray capacitance ~~occurs~~ is present between the wound coils.

In the meantime, in a stacked type inductor, a base body is same as the wire wound type inductor, but green sheets having internal electrodes printed as a spiral shape are stacked ~~in stead~~ instead of a wound coil. Pressurization and sintering are performed on the stacked green sheets, and an external electrode is placed at both ends of the base body. The stacked type inductor is surface mounted on a circuit board and is used for noise elimination or impedance matching, etc., it is appropriate ~~to~~ for mass production and at the same time has an excellent high frequency

characteristic by using Ag (silver) as an internal electrode. On the contrary, because the number of stacked green sheet is limited, there is a limitation ~~in~~ on inductance, and particularly because a width of internal electrode is limited, there is a limitation in permitting sufficient currents. Accordingly, it is inappropriate to use the stacked type inductor for power device, so its use is mainly limited for a low voltage and a low current. In addition, ~~a~~ the fabrication process itself is very intricate and lots of equipment costs are required.

In order to solve above-mentioned problems, an inductor fabricated by forming a metal layer on a cylindrical body and forming a coil pattern on the metal layer by trimming of the metal layer has been presented, however surface mounting of the fabricated inductor is difficult because of its cylindrical shape. On the contrary, a square-shaped inductor is advantageous to surface mounting, however a square-shaped inductor requires much time for trimming a metal layer on the surface of it using a laser, which causes fabrication costs to increase. In addition, variation in a quantity of laser light-interception prevents pattern on the surface of the inductor from forming uniformly, accordingly its electric characteristic lowers.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a surface mountable chip inductor having a good electric characteristic.

In order to achieve above-mentioned object, a spiral pattern is formed at a surface of a cylindrical inductor main body in order to facilitate a fabrication and improve an electric characteristic, and the cylindrical shape is transformed into a square shape in order to facilitate surface mounting.

In more detail, a method for fabricating a surface mountable chip inductor ~~including~~ includes forming a cylindrical body by mixing thermoplastic organic binder with ferrite or ceramic powder, forming a coil pattern on a surface of the cylindrical body, inserting the cylindrical body having the coil pattern into a square-shaped mold, and transforming the cylindrical body into a square-shaped body by pressing it at a certain temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a cylindrical body as a main body of inductor in accordance with the present invention;

Figure 2a illustrates a cylindrical body coated with a metal layer in accordance with a first example of the present invention;

Figure 2b illustrates a cylindrical body having a spiral pattern;

Figure 3a illustrates a cylindrical body having a spiral metal coil pattern on a surface in accordance with a second example of the present invention;

Figure 3b illustrates a method for impregnating metal into a flexible material of the second example of the present invention;

Figure 4 illustrates a method for fabricating a spiral coil pattern in accordance with a third example of the present invention;

Figure 5a illustrates a method for fabricating a spiral coil pattern in accordance with a fourth example of the present invention;

Figure 5b illustrates a method for coating conductive paste on the outer circumference of a body in accordance with the fourth example of the present invention;

Figures 6a to 6d are flow charts illustrating a process transforming a cylindrical body into a square-shaped body;

Wherein Figure 6a illustrates a cylindrical body having a coated layer on the outer circumference;

Figure 6b illustrates a cylindrical body inserted into a square-shaped mold;

Figure 6c illustrates a transformed square-shaped body;

Figure 6d illustrates cut single inductors;

Figures 7a to 7c are flow charts illustrating another process transforming a cylindrical body into a square-shaped body;

wherein Figure 7a illustrates a cylindrical body inserted into a square-shaped mold;

Figure 7b illustrates a transformed square-shaped body;

Figure 7c illustrates cut single inductors; and

Figure 8 illustrates a chip inductor having an external electrode at both ends in accordance with the present invention.

DETAILED DESCRIPTION OF ~~THE~~ PREFERRED ~~EXAMPLE~~ EMBODIMENTS

First, as an inductor main body, ferrite or ceramic powder mixed with a thermoplastic organic binder is formed into a cylindrical shape by a process such as extruding or pressing.

A main body is formed so as to have a cylindrical shape and a coil pattern is formed at a surface of the main body. In a first example of the present invention, a metal layer is formed on a surface of the cylindrical body and a spiral coil pattern is formed on the metal layer.

In accordance with another example of the present invention, a coil pattern is formed by winding a thread-shaped flexible material including conductive paste on the surface of the cylindrical body and hardening the conductive paste included in the flexible material.

In accordance with a still another example of the present invention, a coil pattern is formed by winding a tape having a certain thickness and a width on the surface of the cylindrical body as a spiral shape having a certain interval, coating conductive paste on a distance between the wound tapes, and hardening the coated conductive paste.

In accordance with a further example of the present invention, a coil pattern is formed by winding a flexible material free of conductive paste on the outer circumference of the cylindrical body with a certain interval, coating conductive paste on the outer circumference of the cylindrical body by dipping the cylindrical body in a container containing conductive paste, and hardening the coated conductive paste for a certain time.

The cylindrical body is transformed into a square-shaped body by inserting the cylindrical body having the coil pattern into a square-shaped mold and applying pressure on it at a certain temperature. Accordingly, a chip inductor not only has a good electric characteristic but also is advantageous to surface mounting.

Hereinafter, the method for fabricating a surface mountable chip inductor in accordance with the present invention will now be described in more detail with reference to accompanying drawings.

Figure 1 illustrates a cylindrical body 10 as an inductor main body used for a surface mountable chip inductor. The cylindrical body 10 is fabricated by mixing ferrite or ceramic powder with thermoplastic organic binder transformable by heating, a cylindrical shape can be formed by an extruding method, etc.

When ferrite is used in order to form the cylindrical body, it is preferable to use ferrite such as the group of Ni-Zn, the group of Cu-Zn, the group of Ni-Cu-Zn, etc. appropriate to high frequency.

An organic binder is generally added to the powder before a solid solution is formed by sintering of the powder, in order to form ferrite or ceramic powder into a certain shape and maintain the shape.

The organic binder in the present invention is used for transforming the cylindrical body 10 into a square-shaped body after forming a cylindrical body 10 and a spiral pattern on the surface of the body 10.

Accordingly, it is preferable to use thermoplastic resin such as PVA(polyvinylalcohl), PVB(polyvinylbutyral), polyethylene, polystyrene, polyvinylchloride, polyamide, etc. or its mixture as organic binder in order to make it appropriate to transform the cylindrical body 10 into a square-shape body at a certain temperature (for example, 300°C), however organic binder is not limited to the above-mentioned materials and other materials can be used also.

In the meantime, because the added organic binder is ~~vanished~~ made to disappear, i.e., removed, in the sintering process of the fabricated body, ~~accordingly~~ a solid sintered body that is ~~a solid solution~~ constructed with ceramic or ferrite and various additives is obtained.

The first example for forming a spiral coil pattern on the surface of the cylindrical ceramic body will now be described.

First, as depicted in Figure 2a, a metal layer 15 is coated on the surface of the cylindrical body 10. The metal layer can be coated so as to have a certain thickness by a surface treatment process such as a dipping, a plating or a sputtering, etc.

In the first example, the metal layer 15 is formed by coating Ag. However, as another example, other metal such as Al, Au, Pt, Ni, Cu, Pd, Sn or metal alloy including at least one of them can be used.

Next, as depicted in Figure 2b, spiral pattern is formed at the surface of the cylindrical body 10 having the metal layer 15. A spiral groove 20 is formed at the surface of the cylindrical body 10 by scanning laser on the metal layer 15. ~~According to it~~ Accordingly, a coil pattern having a certain number of wounding is formed at the surface of the cylindrical body 10. In forming of coil pattern, any equipment can be used as long as it can process a fineness groove as a spiral shape.

When laser is used for processing the spiral groove 20, a depth or the number of wounding of the spiral groove 20 can be easily determined by adjusting a scanning power, a scanning time and a focal distance, etc. of laser. For example, a depth of groove can be determined by a scanning power and a scanning time of laser, and a width of groove can be easily determined by adjusting a focal distance of laser. The spiral groove 20 can be processed by rotating the cylindrical body at a certain speed and at the same time reciprocating it back and forth while scanning laser. In this case, the interval between the grooves can be determined by a horizontal movement speed of the cylindrical body 10, a coil pattern having a certain number of wounding can be formed on the cylindrical body 10 by adjusting the horizontal movement speed of the cylindrical body 10.

The spiral groove 20 can be formed more deeply than the thickness of the metal layer 15 so as to reach under the bottom of the metal layer 15 in case of needs.

The method for fabricating the spiral coil pattern in accordance with the second example of the present invention will now be described.

As depicted in Figure 3a, a spiral metal coil pattern is formed on the surface of the cylindrical body 10. In this case, it is preferable to fabricate a thread shaped flexible material 30 including conductive paste as the metal coil. The metal coil is corresponded to a coil of inductor, it is preferable to use Ag, Al, Au, Pt, Ni, Cu, Pd, Sn or metal alloy including one of the elements as the metal coil. In the method for fabricating the spiral coil pattern in accordance with the second example of the present invention, the spiral coil can be formed easier than the first example of the present invention which forms the spiral pattern after coating the metal layer.

As depicted in Figure 3b, the thread-shaped flexible material 30 passes a container 31 containing conductive paste 32, such as metal paste, so that the paste 32 can infiltrate into the flexible material 30. It is preferable to use a combustible material as a flexible material in order for the material to be burnt in the sintering process.

As depicted in Figure 3a, the flexible material 30 including the metal by passing the container is wound on the surface of the cylindrical body 10 as a spiral shape. In more detail, the flexible material 30 including metal is wound on the cylindrical body 10 with a certain interval while the cylindrical body 10 rotates centering around its axis and at the same time transfers in an axial direction at a certain speed. Besides, the spiral coil can be formed by fixing the cylindrical body 10 at a certain position, rotating it centering around an axis and winding the flexible material 30 on the

body 10 with moving the material 30 to the direction of the axis. In order to harden the flexible material 30, the cylindrical body 10 including the spiral coil is left alone for a certain time.

The method for fabricating the spiral coil pattern will now be described in accordance with a third example of the present invention.

As depicted in Figure 4, a tape 40 having a certain thickness and a certain width is wound on the outer circumference of the cylindrical body 10 as a spiral shape. An exposed portion 45 excluding the tape wound portion exists on the cylindrical body 10, conductive paste is coated on the exposed portion 45. Because the conductive paste is coated on the portion excluding the spiral tape wound portion, the conductive paste coated portion also has a spiral shape.

The interval between the metal coils is determined according to a width of the tape 40 wound on the outer circumference of the cylindrical body. In addition, a width of the metal coil formed on the outer circumference of the cylindrical body is determined by the interval between the tapes in the tape wounding process. In addition, approximately the thickness of the metal coil can be determined by a thickness of tape itself. After forming the spiral metal coil on the outer circumference of the cylindrical body, the metal coil is hardened for a certain time.

The method for fabricating the spiral coil pattern will now be described in accordance with a fourth example of the present invention.

As depicted in Figure 5a, a thread-shaped flexible material 50 is wound on the outer circumference of the cylindrical body 10 as a spiral shape having a certain interval. Herein, a material such as nylon, which cannot be infiltrated by conductive paste, is used as a flexible material. Next, as depicted in Figure 5b, in order to coat conductive paste on the outer circumference of the cylindrical body, the cylindrical body 10 wound by the flexible material as a spiral shape is dipped in a container 51 containing conductive paste 52 for a certain time. And, the conductive paste coated on the cylindrical body 10 is hardened for a certain time. Because the conductive paste 52 does not impregnate into the flexible material, the conductive paste coated on the cylindrical body has a spiral shape. It is preferable to eliminate the flexible material from the cylindrical body 10, it is preferable for the conductive paste to have a coated thickness not greater than 1/2 of a diameter of the flexible material.

In the second, the third or the fourth example of the present invention, it is preferable to use a thread-shaped flexible material and tape for forming the spiral coil as a combustible material, also

an incombustible material as a nonconductive material can be used. The cylindrical body having the spiral coil pattern according to above-described methods is transformed into a square-shaped body. Many methods can be used for that, in the preferred example of the present invention, the cylindrical body is inserted into a square-shaped mold and is pressed.

Figure 6a, 6b and 6c illustrate transforming the cylindrical body having the metal layer on the outer circumference into a square-shaped body. First, as depicted in Figure 6a, an exterior coating layer 60 is formed on the outer circumference of the cylindrical body having the spiral coil. The exterior coating layer is formed so as to have a certain thickness by coating a compound of thermoplastic organic binder and ferrite or ceramic powder.

Next, as depicted in Figure 6b, The cylindrical body is inserted into the square-shaped mold, is heated and pressed in order to transform it into a square shape. As shown in Figure 6b, the mold is divided into a lower mold 61 and a upper mold 62. The lower mold 62 has a U shape because of a groove, the cylindrical body can be inserted through the upper portion. After inserting the cylindrical body, the upper mold 62 is combined with the lower mold 61.

In the present invention, because the mold has a square shape, also the transformed body has a square body. However, it is possible also to transform the body into a different shape according to types of surface mounting. The cylindrical body is transformed into a shape of mold by being pressed at a certain temperature inside the mold. Because the cylindrical body includes the thermoplastic organic binder, it can be transformed by heating and pressing process.

In the present invention, after coating the exterior coating layer on the cylindrical body, the cylindrical body is transformed into the square-shaped body. It is also possible to transform the cylindrical body into the square shape first and coat the exterior coating layer on the square-shaped body later.

As depicted in Figure 6d, the square-shaped body can be a single inductor 65 by being cut so as to have a certain length in case of needs. It is cut so as to have a general surface mountable size such as 1608, 2012, etc. By adjusting the size through the cutting, it can be surface mounted same as other stacked type part by the conventional chip mounter.

Another method for transforming the cylindrical body into a square-shaped body will now be described. It is the same method in including steps to heat and press the cylindrical body after inserting it into the square-shaped mold. One thing is different is that the cylindrical body is inserted

into the mold without forming the exterior coating layer and an additional compound is supplied around the cylindrical body inside the mold in order to facilitate transformation into the square shape. Figure 7a illustrates the cylindrical body 10 inside the mold and the compound 70 supplied around the cylindrical body 10 inserted into the mold.

As the compound 70, a mixture of ferrite or ceramic powder and organic binder, which are also used for forming the cylindrical body, is preferably used.

Figure 7b illustrates the transformed square-shaped body inside the mold by the above-described method. As depicted in Figure 7c, the transformed square-shaped body can be a single inductor 75 by being cut so as to have a certain length.

In the meantime, it is possible to press the cylindrical body so as to have the square shape with a square-shaped extruder besides the square-shaped mold.

Figure 8 illustrates a sintered body having an external electrode at both ends. Because the organic binder is vanished when the square-shaped body is sintered in the sintering process, the sintered body is constructed with ceramic or ferrite and various additives.

In accordance with the present invention, defects of the conventional wire wound type and stacked type inductor fabrication processes ~~can be~~ are compensated. By forming a coil pattern on a cylindrical body and transforming the cylindrical body into a square shaped body, an electric characteristic lowering problem is prevented. In addition, ~~a~~ the simple process in the present invention is advantageous to mass production and lowers production cost. Further, a chip inductor in accordance with the present invention can be mounted easily using the conventional chip mounter.

ABSTRACT

In a method for fabricating a surface mountable chip inductor, a spiral coil pattern is formed on a surface of a cylindrical body fabricated by mixing ferrite or ceramic powder with thermoplastic organic binder, the cylindrical body is transformed into a square-shaped body by being inserted into a square-shaped mold and pressure being applied ~~pressure~~ at a certain temperature. An electric characteristic lowering problem can be prevented by forming the coil on the cylindrical body, and transforming the cylindrical body into a square-shaped body ~~is advantageous~~ to improve surface mounting.